"Analysis of Energy Consumption in WSN by Considering Bridge test SHM Application"

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ABSTRACT

Wireless Sensor Network is the wireless network which is the combination of autonomous sensors to monitor or control environment conditions. Information that are to be collected or sensed are temperature, pressure, humidity, motion, heat, sound, light, electromagnetic field, vibration, images, pollutants The Wireless Sensor Network is composed of a significant number of autonomous nodes deployed in an extensive or remote area. In WSN, the sensor nodes have a limited transmission range, processing speed and storage capabilities as well as their energy resources are also limited. In WSN all nodes are not directly connected. The primary objective for all kind of WSN is to enhance and optimize the network lifetime i.e. to minimize the energy consumption in the WSN. There are lots of applications of WSN out of which this research paper focuses upon the Structural Health Monitoring application in which 60 Meter and 100 Meter bridge has been taken as a test application for the simulation purpose.

Keywords: WSN, SHM, Castalia, Routing Protocols

1. INTRODUCTION

Wireless Sensor Network is the wireless network which is the combination of autonomous sensors to monitor or control environment conditions. Information that are to be collected or sensed are temperature, pressure, humidity, motion, heat, sound, light, electromagnetic field, vibration, images, pollutants etc.[1,2,3,4]. The popularity of WSN has increased due to growth in Micro-Electro-Mechanical Systems (MEMS) technology. The concept of wireless sensor networks is based on a simple equation: Sensing + CPU + Radio = Thousands of potential applications [5].

WSN suits the application requirements in comparison with wired sensing systems, since it is easily deployable and reconfigurable even in an inaccessible areas and reduces the system installation and condition monitoring cost in general. Wireless sensor network enables low-cost sensing of environment. Wireless sensor networks are well suited for the structural health monitoring for buildings [6], wind turbines [7], coal mines [8], tunnels [9] and bridges [10,11]. To monitor a structure, we measure behavior (e.g. vibration, displacement) of structure, and analyze health of the structure based on measured data.

2. KEY PROBLEMS FOR SHM

The key problems for developing the SHM system in conjunction with WSN are summarized as follows [12-16]:

A. Compatibility between different sensors, their sampling frequencies and operational modes

In the field of SHM, various types of sensors are used like accelerometer, resistance strain, piezoelectric vibration, optical fiber strain, dip angle, acoustic emission, and stress measurement sensors. All these sensors have different physical mechanisms. Thus the choices of the sensor network sampling frequency, from several Hz to several hundreds of kHz, working mode, and compatibility must be considered while choosing each node.

B. Transmission Bandwidth

Generally WSNs are used for low-bandwidth applications. But in some applications, the data from vibration measurements as well as those resulting from image acquisition require a higher transmission bandwidth.

C. Synchronization

The signals must be sampled synchronously by the nodes; otherwise there will be incorrect information, due to samples grouped together coming from different times of the vibration phase, resulting in an incorrect vibration model judgment.

D. Energy Issues

Each function of a WSN, such as self-organize ability, adaptability, signal sampling, information fusion, signal processing and signal transmission requires energy consumption. Energy consumption issues various with application scenarios.

E. Topology and Data Fusion

WSNs need different topologies to meet the needs of different application characteristics in SHM. Typical topologies include star, cluster tree, and mesh networks.

3. OVERVIEW OF CASTALIA SIMULATOR

Castalia is a simulator for Wireless Sensor Networks (WSN), Body Area Networks (BAN) and generally networks of low-power embedded devices. It is based on the OMNeT++ platform and can be used by researchers and developers who want to test their distributed algorithms and/or protocols in realistic wireless channel and radio models, with a realistic node behaviour especially relating to access of the radio. Castalia can also be used to evaluate different platform characteristics for specific applications, since it is highly parametric, and can simulate a wide range of platforms. The main features of Castalia are: [13]

A. Advanced channel model based on empirically measured data

- ✓ Model defines a map of path loss, not simply connections between nodes
- ✓ Complex model for temporal variation of path loss
- ✓ Fully supports mobility of the nodes
- ✓ Interference is handled as received signal strength, not as separate feature

B. Advanced radio model based on real radios for low-power communication.

- ✓ Probability of reception based on SINR, packet size, modulation type. PSK FSK supported, custom modulation allowed by defining SNR-BER curve.
- ✓ Multiple TX power levels with individual node variations allowed
- ✓ States with different power consumption and delays switching between them
- ✓ Realistic modeling of RSSI and carrier sensing

C. Extended sensing modeling provisions

- ✓ Highly flexible physical process model.
- ✓ Sensing device noise, bias, and power consumption.

D. Node clock drift
E. MAC and routing protocols available.
F. Designed for adaptation and expansion.

Concerning the last bullet, Castalia was designed right from the beginning so that the users can easily implement/import their algorithms and protocols into Castalia while making use of the features the simulator is providing. Proper modularization and a configurable, automated build procedure help towards this end. The modularity, reliability, and speed of Castalia is partly enabled by OMNeT++, an excellent framework to build event-driven simulators [OMNeT++ link].

4. RESULTS AND DISCUSSION

In this research paper the comparison has been done in between GPSR (Greedy Perimeter Stateless Routing), Multipath Ring Routing and no routing. The codes for Castalia simulator for individual algorithms have been developed. Post the design of Castalia code, simulations was run by considering the 60 and 100 meter Bridge test, which is one of the SHM applications, by taking constant values of pre-defined variables and the corresponding results were noted down. This research work has analyzed simulation results for 60m and 100m bridge.

A. Simulation Setup:

To explore the results, it has been conducted a detailed simulation using a Castalia 3.2 designed for Wireless Sensor Networks (WSN) and generally networks of low-power embedded devices. In this simulation no of sensors from 9 to 49 for 60m bridge and 100m Bridge Test, one of the SHM application. The simulation setup for 60m and 100m Bridge Test has been shown here:

Table 1: Simulation Parameters for 60m Bridge Test

Sr No.	Parameter Name	Value
1	Application Name	60 meter Bridge Test, SHM Application
2	Simulation Time	100 s
3	X axis	60 m
4	Y axis	10 m
5	No of sensor nodes	5
6	Deployment Type	Grid, [0]-->center[1..9]; 4×2
7	Routing Protocols	GPSR, Multipath Ring, No Routing
8	Sink Node	Node 0
9	Radio Type	CC2420

Table 2: Simulation Parameters for 100m Bridge Test

Sr. No.	Parameter Name	Value
1	Application Name	100 meter Bridge Test, SHM Application
2	Simulation Time	100 s
3	X axis	100 m
4	Y axis	20m
5	No of sensor nodes	5
6	Deployment Type	Grid, [0]-->center[1..9];4x2
7	Routing Protocols	GPSR, Multipath Ring, No Routing
8	Sink Node	Node 0
9	Radio Type	CC2420

When no. of sensor nodes are 9, 19, 29,39 and 49 then respective deployment type will be Grid, [0]- > Center; 4×2, 9×2, 14×2, 19×2 and 24×2 and their relative energy consumption for GPSR, multipath ring routing and no routing schemes and is shown as following:

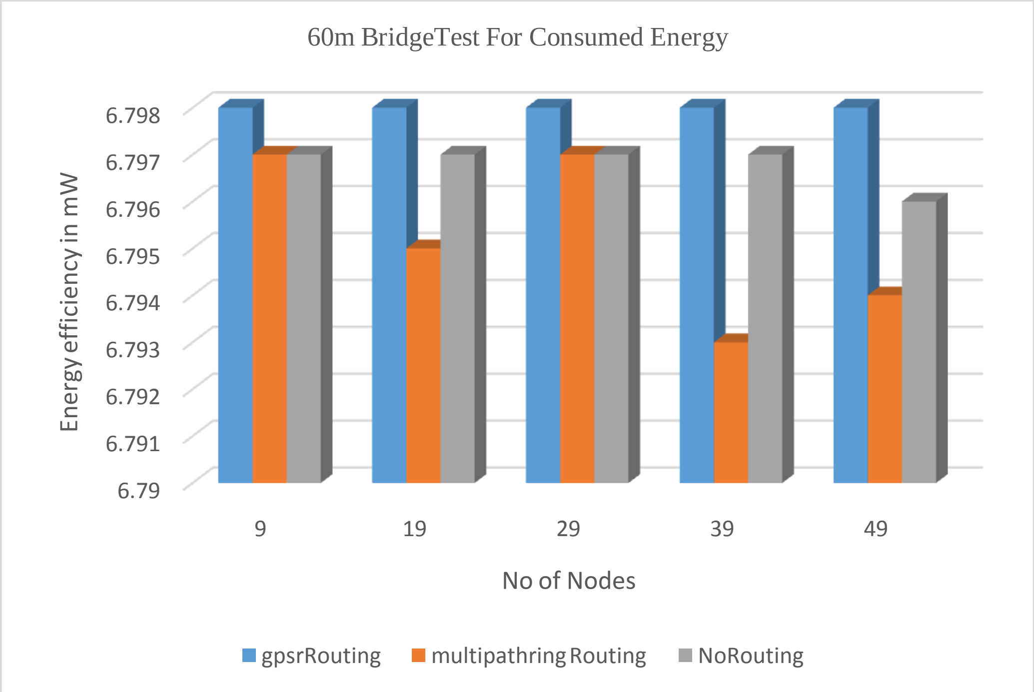

Fig. 1: Energy consumption with 9,19,29,39 and 49 no. of nodes.

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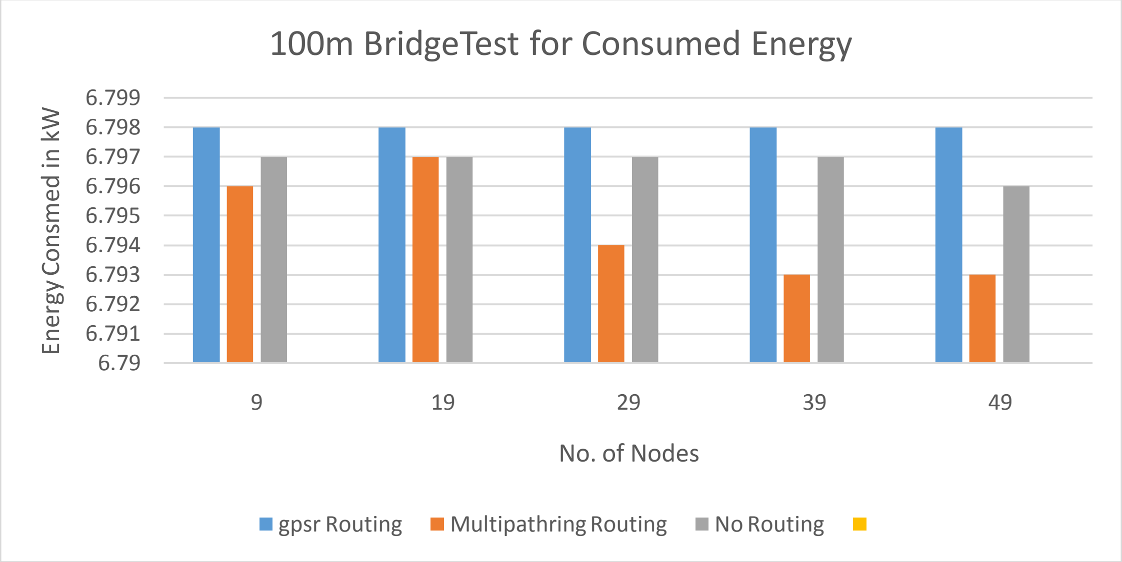

Fig. 2: Energy consumption with 9, 19, 29, 39 and 49 no. of nodes.

5. RESULT ANALYSIS & CONCLUSION

From above results it has been notified that as the no. of nodes increases then the energy consumption decreases in multipath ring routing as compare to GPSR routing and no routing. In 100m Bridge Application, energy consumption for GPSR routing and no routing are same as in 60m Bridge Application. After analysis of the above graphs it is clear that the average energy consumption of Multipath Ring routing protocol is minimum among all other routing protocols such that no Routing, GPSR Routing. GPSR allows nodes to figure out who its closest neighbors are (using beacons) that are also close to the final destination, from where the information is supposed to travel. To calculate a path, GPSR uses a greedy forwarding algorithm that will send the information to the final destination using the most efficient path possible. If the greedy forwarding fails, perimeter forwarding will be used which routes around the perimeter of the region.

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